Discussion on Seismic Exploration in the Northwest Territories, 2000-2003

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TABLE OF CONTENTS

ABSTRACT ..... **V**

RÉSUMÉ ..... **VI**

INTRODUCTION **1**

History 2
Today 3
Regulatory Regime 3

TYPES OF SEISMIC CURRENTLY USED IN THE NWT **5**

MARINE (OFFSHORE) 3-D SEISMIC USING AIRGUNS **6**

Lessons Learned *8*
Next Steps *9*

RIVERINE 2-D SEISMIC USING AIRGUNS **9**

Lessons Learned *12*
Next Steps *13*

LAND BASED SEISMIC 2-D AND 3-D PROGRAMS **14**

2000/2001 15
Lessons Learned *18*
2001/2002 19
Lessons Learned *21*
2002/2003 24
Next steps *25*

SUMMARY **26**

ACKNOWLEDGEMENTS **26**

REFERENCES **27**

LISTOF FIGURES

Figure 1. Land claim areas in the Northwest Territories and Nunavut (Clark 2000) 4

Figure 2: Instantaneous pressure change values (IPC) vs. setback distance for 2.0 kg charges recorded with Hydrophone 1, open water conditions (Aug. – Sept. 2000)... 16

Figure 3. Instantaneous pressure change (IPC) values vs. setback distance for 2.0 kg charges recorded with Hydrophone 1, waterbodies not frozen to the bottom (Jan. – April 2001). 18

Figure 4: Instantaneous pressure change (IPC) values vs. setback distance for 2.0 kg charges recorded with Hydrophone 1, waterbodies not frozen to the bottom (Jan. – April 2002). 22

LIST OF APPENDICIES

Appendix 1: Table 1. Setback distance (m) from centre of detonation of a confined explosive to fish habitat to achieve 100kPa guideline criteria for various substrates (Wright and Hopky 1998) – Erratum updated December 6, 2000. 31

Appendix 2: DFO Western Arctic Area 2001/2002 Protocol for Monitoring the Use of Dynamite in Waterbodies not Frozen to the Bottom..... 32

Appendix 3: DFO Protocol for Water Withdrawal for Oil & Gas Activities in the Northwest Territories 34

Appendix 4: DFO Protocol for Temporary Winter Access Water Crossings for Oil & Gas Activities in the Northwest Territories..... 35

Appendix 5: Letter dated February 14, 2003 RE: DFO Recommendation – Explosives Should Not Be Used To Conduct Seismic Exploration In Areas Of Waterbodies Not Frozen To The Bottom 36

ABSTRACT

Cott, P. A., B.W. Hanna and J.A. Dahl. 2003. Discussion on seismic exploration in the Northwest Territories 2000–2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2648: vi +36 p.

Favorable oil and gas prices have renewed interest in the vast hydrocarbon deposits in the Northwest Territories (NWT). Major seismic and drilling exploration programs were initiated in 2000 at a scale not seen since the 1970s and early 1980s. Many of the challenges from decades ago remain (remote locations, harsh climates, limited operating seasons), but companies are facing many new challenges such as a complex and time consuming environmental assessment and regulatory regime and increased environmental monitoring and mitigation requirements. Land-based and marine seismic programs, both 2-D and 3-D, were conducted in the NWT between 2000 and 2003, many using new technologies or technologies never before used in the north. The Department of Fisheries and Oceans – Western Arctic Area was on the front line of regulating this booming industry, developing and implementing intensive monitoring and testing programs to assess the impacts seismic operations have on fish and fish habitats. These programs were conducted in a stepwise, adaptive management fashion and have yielded a significant amount of new information. This information instigated the development of operational protocols and the decision to no longer allow explosive-based seismic exploration on waterbodies not frozen to the bottom in the NWT due to the likely negative impacts on fish.

Key Words; Northwest Territories; NWT; Mackenzie Delta; Arctic; oil and gas exploration; seismic; explosives; mitigation; water withdrawal; water usage; precautionary approach

RÉSUMÉ

Cott, P. A., B.W. Hanna et J.A. Dahl. 2003. Discussion sur la prospection séismique dans les Territoires du Nord-Ouest en 2000–2003. Can. Manuscr. Rep. Fish. Aquat. Sci. 2648: vi +36 p.

Les prix avantageux du pétrole et du gaz ont ravivé l'intérêt à l'égard des vastes dépôts d'hydrocarbure dans les Territoires du Nord-Ouest (T.N.-O.). D'importants programmes de prospection séismique et de forage ont été entrepris en 2000, à une intensité inégalée depuis les années 70 et le début des années 80. Outre les défis de cette époque qui demeurent présents (localités éloignées, climat rigoureux, saisons d'activité brèves), les entreprises doivent faire face aux nouvelles réalités, comme les régimes complexes d'évaluation et de réglementation environnementales qui exigent beaucoup de temps, ainsi que la surveillance et les exigences accrues relatives aux mesures d'atténuation des impacts environnementaux. Des programmes séismiques terrestres et marins, 2-D et 3-D, ont été réalisés dans les T.N.-O. entre 2000 et 2003, dont plusieurs à l'aide de nouvelles technologies ou de technologies qui n'avaient jamais été utilisées dans le Nord. La région de l'Ouest et de l'Arctique du ministère des Pêches et des Océans a été le chef de file de la réglementation de cette industrie en pleine expansion en élaborant et en mettant en œuvre des programmes de surveillance et d'essai pour évaluer les répercussions des activités séismiques sur les poissons et sur leur habitat. Ces programmes ont été réalisés selon une méthode de gestion progressive et adaptive qui a produit une quantité importante de nouvelles données. Ces nouvelles données ont suscité l'élaboration de protocoles fonctionnels et entraîné la décision d'interdire la prospection séismique par explosion dans les plans d'eau des T.N.-O. qui ne sont pas gelés en profondeur, en raison des répercussions néfastes sur le poisson.

Mots réservés : Territoires du Nord-Ouest; T.N.-O.; delta du Mackenzie; Arctique; prospection pétrolière et gazière; prospection séismique; explosifs; atténuation; consommation d'eau; usage de l'eau; approche préventive

INTRODUCTION

The Northwest Territories (NWT) has one of the fastest growing economies in Canada, spurred on by the oil and gas industry and the recently established diamond mining industry (NWT Bureau of Statistics 2003). Many large hydrocarbon reserves discovered decades ago remain undeveloped, but the sharp rise in the price of oil and gas coupled with an increasing U.S. demand for gas, has prompted a new wave of interest in hydrocarbon exploration and development. Canadian gas exports to U.S. markets have the potential to increase 47% by 2025 over current levels (U.S. Energy Administration 2003). Given that western Canadian reserves are dwindling and Atlantic Canada will likely only be able to meet a small proportion of the increased demand from the U.S., the NWT is poised to become a major exporter.

Further incentive for exploration is the proposed Mackenzie Valley Pipeline that would bring these northern gas reserves to southern markets. If this pipeline is built it will be one of the largest development projects in Canada with a four billion dollar price tag and the creation of 5000 person years of direct employment (RWED 2003a).

The purpose of this paper is to document the role the Department of Fisheries and Oceans (DFO), Western Arctic Area, Fish Habitat Management had in regulating seismic exploration in the NWT from 2002 to May 2003 and key decisions that were made. Decisions made by DFO were under the auspices of the precautionary approach (DFO 2002).

History

The presence of hydrocarbons in the NWT has been known for centuries with aboriginal peoples utilizing oil from natural seeps along the Mackenzie River near present day Norman Wells. However, it was not until 1920 that the first oil well was drilled; a refinery was then established in 1933. The pace of activity increased exponentially with World War II when the 600 mile Canol pipeline was constructed to bring the Norman Wells oil to Whitehorse, where a separate line transported it to the U.S. army base in Fairbanks, Alaska. After the war, the pipeline was dismantled but interest in exploration continued to increase. During the 1950s and 1960s exploration activity was occurring in the southern NWT, the High Arctic, and the Mackenzie Delta/Beaufort Sea. The biggest event to spur exploration in the north was a huge oil discovery in Prudhoe Bay, Alaska in 1967. In the 1970s oil and gas activity accelerated in the NWT and included the drilling of offshore wells in the Beaufort Sea. However, in 1977 the Berger Inquiry recommended a 10-year moratorium be put on the construction of a gas pipeline in the NWT. Despite the Berger decision, activity continued in the early 1980s, mainly based on government subsidies from the federal Liberal government's National Energy Program. During this time Imperial Oil developed the Norman Wells oilfield and subsequently constructed a pipeline from Norman Wells to Zama, Alberta. In 1985 the newly elected Conservative government eliminated the National Energy Program. This in conjunction with a decline in the price of oil led to the reduction of oil and gas exploration in the north. This hiatus continued until the late 1990s when rising gas prices made the north an attractive investment for the oil and gas industry once again (Janicki 2001).

Today

Hydrocarbon exploration in the Mackenzie Delta region has been booming since 2000. For example, during the 2001/2002 season, eight companies conducted five exploration drilling programs and twelve seismic exploration programs shooting over 11,000 kilometres of seismic lines. Eleven of the seismic programs used dynamite as the energy source, requiring thousands of kilograms of explosives. Other locations in the NWT experiencing high rates of exploration and development include the Fort Liard area in the southwest, Cameron Hills just north of the Alberta border, the Colville Lake area near Norman Wells, and the Beaufort Sea and Mackenzie River. With the possibility of a Mackenzie Valley Pipeline looming, companies have been busily conducting seismic exploration and exploratory drilling in hopes of better defining known reserves and discovering new reserves. If a pipeline does go ahead, expanded exploration and the development of much smaller reserves could become economically viable as the gas would no longer be stranded for an indefinite period (RWED 2003b, RWED 2003c). With increased exploration come many spin-off activities and developments that could have impacts on fisheries resources and fish habitat, such as winter road and all season road construction, exploration wells, sumps, gravel quarries, staging areas and barge landings.

Regulatory Regime

Many challenges that faced the industry decades ago remain the same. Remote locations, extreme temperatures, sensitive environments, short operating windows and

high operating costs are still factors: however the regulation of the industry has changed dramatically. The NWT is divided into six land claim settlement areas: the Inuvialuit, Gwich'in and Sahtu claims have been settled while the North Slave, South Slave and Deh' Cho claims are still being negotiated (Clarke 2000)(Figure 1).

Figure 1. Land claim areas in the Northwest Territories and Nunavut (Theresa Nichols, DFO, (from Clarke 2000))

In 1999, as part of land claim negotiations, the *Mackenzie Valley Resource Management Act* (MVRMA) replaced the *Canadian Environmental Assessment Act* (CEAA) as the main instrument of environmental assessment for all of the NWT south of

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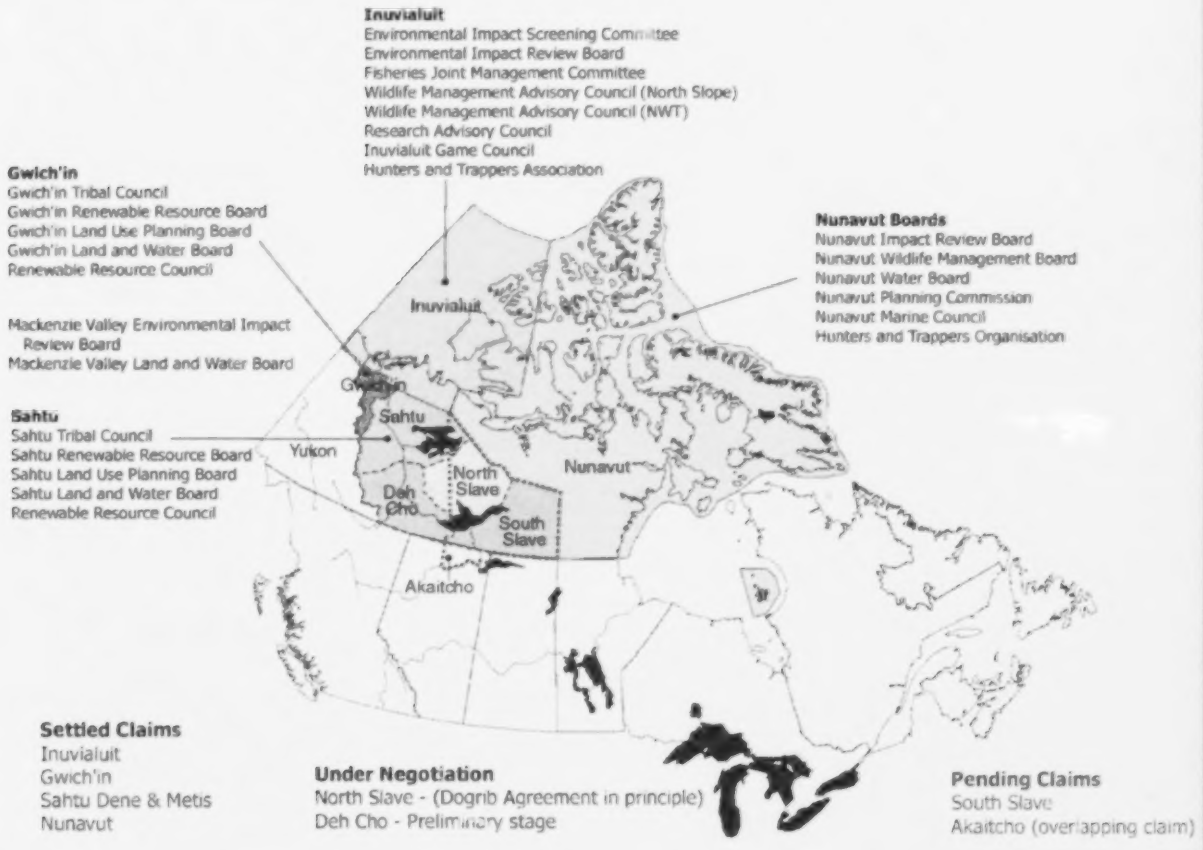

Figure 1. Land claim areas in the Northwest Territories and Nunavut (Theresa Nichols, DFO, (from Clarke 2000))

In 1999, as part of land claim negotiations, the *Mackenzie Valley Resource Management Act* (MVRMA) replaced the *Canadian Environmental Assessment Act* (CEAA) as the main instrument of environmental assessment for all of the NWT south of

the Inuvialuit Settlement Region (ISR). With the MVRMA came the establishment of three separate Land and Water Boards that are responsible for issuing land use permits and water licences for proposed developments in the Mackenzie Valley. In the ISR, CEAA still applies, as does a similar environmental assessment process under the *Inuvialuit Final Agreement*. Indian and Northern Affairs Canada (INAC) and the NWT Water Board are still responsible for the issuance of land use permits and water licences respectively.

The National Energy Board (NEB) is responsible for permitting oil and gas activities under the *National Energy Board Act*, the *Canada Petroleum Resources Act* and the *Canada Oil and Gas Operations Act* (L. Van Ham, NEB *pers. comm.*). DFO participates in all three of the environmental assessment processes, providing advice in the development of other regulators' licences and permits as well as regulating under the *Fisheries Act* and *Navigable Waters Protection Act*. To help guide industry through the complex environmental assessment and regulatory regime in the NWT, INAC commissioned the development of a series of "Regulatory Road Maps" (Erlandon and Associates Consultants 2002). They are similar to those prepared for the Nova Scotia and Newfoundland offshore areas.

TYPES OF SEISMIC CURRENTLY USED IN THE NWT

Both 2-D and 3-D seismic methodologies are applied in the NWT. Generally the linear 2-D programs are intended for initial reconnaissance to determine whether further exploration is warranted. The grid-pattern of 3-D seismic programs provides higher resolution of hydrocarbon reserves giving a better indication of where to commence

exploratory drilling (Bott 1999). Seismic programs have been conducted throughout the NWT on land (including over inland lakes), in the near-shore Beaufort Sea, in the off-shore Beaufort Sea, down the Mackenzie River, and within the channels in the Mackenzie Delta. The marine and river seismic programs utilize airguns as the energy source, with the airguns configured in arrays and towed behind a vessel. On land, both explosives and vibroseis units are used as energy sources, with programs in mountainous areas or difficult terrain being facilitated by the use of high floatation tracked or balloon tired vehicles, or heli-portable units. Most of the seismic exploration conducted over inland waterbodies not frozen to the bottom has been done using explosives as the energy source.

MARINE (OFFSHORE) 3-D SEISMIC USING AIRGUNS

Anderson Exploration Ltd. (Anderson), now Devon Canada Limited, conducted a marine seismic survey in the Beaufort Sea during open water conditions in 2001/ 2002. The survey covered an area of 5, 436 km^2 (140 km in length and approximately 60 km across at its widest point), and was designed to acquire 1700 km^2 of seismic data (IEG 2001). A bathymetric survey of the program area was conducted prior to the seismic program in order to identify navigation hazards and determine water depth. The survey involved the use of an echo sounder, side scan sonar, a sub-bottom profiler, and a magnetometer (IEG 2001). For the actual seismic program, a 67.4 metre long ice breaker was utilized. Two 2250 cubic inch airgun arrays composed of 750 cubic inch subarrays were towed behind the vessel and provided the energy source for acquiring data. Three 4

km long streamers containing hydrophones were also towed behind the boat to record the incoming data (IEG 2001).

In the summer of 2001, favorable conditions allowed Anderson to almost complete the entire two-year seismic program in the first year. However, due to pack ice problems in the summer of 2002, not all of the remaining data were acquired.

This project underwent an environmental screening both under the *Inuvialuit Final Agreement* and CEAA prior to being approved and permitted. DFO's involvement in this process consisted of providing a Letter of Advice directly to Anderson Exploration and specialist advice to the Environmental Impact Screening Committee and the NEB who were conducting the respective screenings. DFO required acoustic monitoring to be conducted to determine the extent and attenuation of sound waves generated by the airguns. Marine mammal monitoring was also required and consisted of aerial surveillance as well as on board monitors. A 1000 metre shutdown radius was implemented in the event that beluga (*Delphinapterus leucas*) and/or bowhead whales (*Balaena mysticetus*) were sighted. The airguns were shut down if a whale was observed within this radius and remained so, until such time as the whale cleared the zone. A "ramp up" procedure was required (starting with firing one airgun and gradually increasing to full array) to provide marine mammals and fish with the opportunity to leave the program area prior to being subjected to the full volume of the array. Timing restraints were also placed on the program whereby operations could not begin until the conclusion of the annual mid-summer harvest for beluga whales.

Lessons Learned

The monitoring result from the 2001 marine program demonstrated that bowheads, not belugas were the most frequently seen cetacean species and were the reason for the majority of the shut downs in the program. Of the 280 whales identified to species level from the seismic vessel, 262 were bowheads and 18 were beluga. There were seven occasions where beluga were sighted ranging in distance from 614 metres to 2508 metres. All were seen either before or within one hour of the commencement of seismic operations, and they were all "swimming away" from the seismic vessel. When combined with aerial monitoring results, beluga whales seemed to have an avoidance distance of 10-20 km from the seismic operation. Bowhead whale displacement from the area of the seismic operation was indicated by vessel based monitoring results, but not to an extent that it could be detected by the broad-scale aerial surveys. The most commonly observed bowhead behaviour was "swimming", with some "diving", but there was no visually detected increase in "swimming away" behaviour when the airguns were operating in contrast to when the airguns were not operating (LGL Ltd. and Jasco Research Ltd. 2001). Based on visual observation, seals did not seem to avoid the seismic vessel during operation. However, seals appeared to be spending time at the surface (rather than diving) possibly to avoid exposure to higher sound if they were underwater (LGL Ltd. and Jasco Research Ltd. 2001). In addition, the seismic program did not appear to affect the timing or route of the western fall migration of ringed seals (*Phoca hispida*). Four seals were tagged and tracked in 2001, and traveled close to or through, the project area while the seismic vessel was operating. In the following year, an additional four seals were tagged and they followed similar routes and timing as the

2001 tagged seals, with the difference being that there was no seismic activity in the offshore in 2002 (Harwood *et al.* 2002; L. Harwood, DFO *pers. comm.*). In the Alaskan Beaufort Sea, Harris *et al.* (2001) noted that seals did not react dramatically to seismic operations. Not all seals swam away from airguns in operation, those that did appeared to not move much beyond 250 metres.

On future projects, more modern and effective marine mammal monitoring methods (satellite tagging rather than aerial surveys) will be required as weather and animal behavioural factors can easily bias survey results. Also, more emphasis should be placed on investigating the potential impacts on fish and marine invertebrates.

Next Steps

With the program now completed, DFO is awaiting the final monitoring report to be submitted for review. The summer seismic program of 2001/2002 was successful in delineating many potential offshore reserves, prompting Devon Canada Ltd. to submit a project description for a Beaufort Sea exploratory drilling program to the NEB in May 2002. This drilling program will require a comprehensive study under CEAA and DFO will be a Responsible Authority due to likely *Fisheries Act* requirements.

RIVERINE 2-D SEISMIC USING AIRGUNS

Aquatic-based seismic in the NWT entered a new phase in 2002 with two companies proposing seismic projects in riverine environments. If approved, they will be the first projects of this type to be conducted in Canada.

WesternGeco has proposed to conduct a 2-D seismic program for the entire length of the Mackenzie River from the Delta to the confluence of the Mackenzie and Liard Rivers, and then continue on the Liard River, for a total distance of more than 2,000 kilometres. The barge mounted seismic equipment would be comprised of a 1500 cubic inch airgun array, composed of two 750 cubic inch subarrays, and a 600 - 2000 metre long streamer containing acoustic pressure sensors to record the data (WesternGeco and IMG Golder 2002).

Because of the different regulatory regimes in the NWT, this project was broken into two separate applications: 1) the Mackenzie Delta portion falling under *CEAA* and the *Inuvialuit Final Agreement*, and 2) the Mackenzie/Liard River portion falling under the MVRMA. Both projects were referred to an Environmental Assessment (EA) (higher level review above screening) due to uncertainties in regard to potential impacts (referred by the Environmental Impact Screening Committee in the ISR and by DFO and the NEB in the Mackenzie Valley). Although much research has been done on offshore seismic, literature regarding biological impact monitoring of riverine seismic is extremely limited if not absent.

The exploration program was delayed for a year until a test program, intended to answer outstanding questions regarding potential impacts, could be conducted. Specifically, DFO required testing to be conducted to verify the proponent's predictions on sound propagation and physiological and behavioural effects on fish. Marine mammals and fish can exhibit behavioural disturbance when exposed to noise levels of 160 dB and higher, with injury predicted at 220 dB (WesternGeco and IMG Golder 2002). This was the first time this type of testing had ever been conducted in a riverine

environment. In order to test different channel morphologies, three 90 km stretches of the Mackenzie River and channels within the Mackenzie Delta were selected as test areas.

Caged fish tests were conducted to assess physiological impacts with a broad range of native fish species found in the Mackenzie River (burbot (*Lota lota*) (n=2), flathead chub (*Platygobio gracilis*) (n=17), longnose sucker (*Catostomus catostomus*) (n=36), northern pike (*Esox lucius*) (n=13), pearl dace (*Margariscus margarita*) (n=126), slimy sculpin (*Cottus cognatus*) (n=2), trout-perch (*Percopsis omiscomaycus*) (n=8) and walleye (*Stizostedion vitreum*) (n=1)) of various lengths (range 37-357 mm) (WesternGeco and IMG Golder 2003). Although initially recommended by DFO, coregonids were not included in this study due to the risk of high temperatures increasing handling related mortalities (J. Kelso, Golder Associates *pers. comm.*). As the caged fish test was designed to assess the effects on fish exposed to different sound levels, testing was conducted in only one location on the river using a seismic vessel moored to the Canadian Coast Guard dock at Norman Wells. Cages of fish were placed at distances of 2, 85, and 446 metres away from the airgun array in order to have fish exposed to sound levels of 224 dB, 193 dB and 169 dB (peak level) respectively. The test was repeated twice and included a control site at background levels (WesternGeco and IMG Golder 2003). Eighteen of the fish used in the cage test were sacrificed for hystopathological investigation of sub-lethal effects.

Fish behaviour was assessed using hydro-acoustics in order to address concerns of potential disturbance such as "fish herding" in front of the seismic vessel during firing of the airgun array. Transects were run perpendicular to the river in the three study

locations for ten transects in total. Each of the transects were run five times; pre-airgun ramp-up (control), well in advance of the operating seismic vessel, directly in front of the vessel, directly behind and well behind after the vessel had passed. Fish density and distribution data were then analyzed to determine if any change had occurred as a result of the seismic operation (WesternGeco and IMG Golder 2003).

Lessons Learned

From the acoustic testing it was determined that the sound from the airgun array traveled much further than predicted (e.g. 160 dB peak measured 3602m from source at a depth of 10 m in the Mackenzie Delta) (WesternGeco and IMG Golder 2003) compared to the calculated values that were initially anticipated. (e.g. 160 dB peak at 60 m from the source) (WesternGeco and IMG Golder 2002). The extent and attenuation rate of sound was dependent on factors such as water depth, substrate type and the presence of sandbars (WesternGeco and IMG Golder 2003).

No direct mortality of caged fish attributed to the seismic program was observed after a 48 hour holding time, although some fish in the cage nearest the airgun array were temporarily stunned recovering within a ½ hour after exposure. Four fish from cages exposed to the lowest sound levels died due to handling stress. There were no mortalities or stunned fish observed in the river by the onboard monitors or the monitors trailing the seismic vessels in small boats. No mortalities attributed to the seismic program were observed along the riverbanks by the community monitors (WesternGeco and IMG Golder 2003). However, due to the high sediment load it would be very difficult to see dead or stunned fish in the Mackenzie River (S. Stephenson, DFO *pers. comm.*). The fact

that no direct mortalities of fish were observed during testing was encouraging, although as stated above they would be hard to detect. Although the behavioural and histopathology aspects of the test did not show any negative effects attributed to the airgun based seismic operation, it is the opinion of DFO that the results of the behavioral and histopathology studies were inconclusive.

Between the WesternGeco and Northern River Surveys programs (discussed below), DFO has an opportunity to obtain significant information regarding the potential negative impacts of conducting airgun based seismic exploration in a riverine environment. The importance of DFO involvement in the development of any test program became evident; this holds true regarding monitoring during the production program stages as well. It is necessary to ensure that the information obtained is as conclusive and complete as possible and that study limitations are clearly presented, as such studies will undoubtedly be used as reference material in other areas where similar undertakings are being considered.

Although regulators recognize that airgun seismic is likely less harmful to fish than explosive based seismic exploration in waterbodies, the public often has the perception that the impacts of any seismic activity is similar to the heavy use of explosives in the 70s and early 80s. Many anecdotal reports of fish kills from that era and public concern regarding seismic exploration still emerge (Tallman and Reist 1997).

Next Steps

The WesternGeco project(s) are on hold awaiting the results of the test programs. Test results have been submitted and the EA process in both regions has been restarted.

Northern River Surveys also proposed a 2-D seismic program. The project would involve the acquisition of seismic data from both the Liard and South Nahanni rivers with a total distance of 160 km (Lorrnel Consultants 2002). In this program, a barge would tow a 1200 cubic inch airgun array as the energy source, and hydrophones would be placed on the riverbed close to shore to record the data. This project, although much smaller in size than the Mackenzie/Liard project poses the same questions regarding impacts. A preliminary screening under the MVRMA was conducted by the NEB, and DFO issued a Letter of Advice to Northern River Surveys Ltd. that was contingent on a test program being conducted prior to the initiation of the full seismic program. No test program has yet been submitted to DFO for review and comment. This program has since been referred to an EA by the Mackenzie Valley Environmental Impact Review Board and is currently on hold. If and when this EA is reactivated, DFO will be able to apply lessons learned in the WesternGeco process to this project.

LAND BASED SEISMIC 2-D AND 3-D PROGRAMS

Since 2000, the majority of seismic exploration projects occurring in the NWT have been concentrated in the Mackenzie Delta area within the Inuvialuit Settlement Region (ISR). This seismic activity peaked in the winter of 2001/2002, during which time explosive-based seismic programs were shot in more than forty waterbodies that were not frozen to the bottom and likely provided fish over-wintering habitat. These waterbodies included large and small lakes of varied bathymetry, channels of the Mackenzie River, and the near-shore Beaufort Sea.

2000/2001

In August and September 2000, Gulf Canada Resources Ltd. (now ConocoPhilips) conducted an equipment test at Parsons Lake, approximately 65 kilometres north east of Inuvik. The test was intended to evaluate the use of explosives to obtain seismic data in open water conditions in order to determine the feasibility of conducting a 3-D seismic program in Parsons Lake during the summer of 2002. Seismic exploration using explosives at Parsons Lake had not been conducted since 1975 (Golder Associates 2000). Different charge size/setback distance combinations were tested to determine which would yield the best seismic signal without exceeding the 100 kPa threshold outlined in the *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* (Wright and Hopky 1998) (hereafter referred to as the "Guidelines"). A Section 32 *Fisheries Act* Authorization was issued and requirements for instantaneous pressure change (IPC) monitoring were stipulated. IPC monitoring was conducted using Instatel® seismograph units and 2 hydrophones.

Of the 30 charges monitored, 43.3% had IPC's greater than 100 kPa despite being buried deeper than the setback distances outlined in the Guidelines. Figure 2 presents the IPC values obtained from the monitoring of 2 kg charges with hydrophone 1 (the hydrophone directly above the shot hole (e.g. 10 m away from a charge set back 10 m), other charge sizes were experimented with. Eight fish were confirmed killed during this test program (Golder Associates 2000). It has been well documented that the use of explosives in aquatic environments has the potential to negatively impact fish (Wright 1982), hence the development of DFO's Guidelines. Of the 3 drills tested, hammer drills and Vibra-ram® did not set charges into consolidated substrates as consistently as

conventional casing drills. As a result of these tests, a full-scale 3-D seismic program during open water conditions was not proposed. Since this test was conducted, several anecdotal accounts of schools of dead fish being washed up on the shores of Parsons Lake have been reported to DFO. Such reports suggest that not all explosive induced fish mortalities are immediate and/or that mortalities may not be readily observable (i.e. sinking to the bottom and only becoming buoyant when decomposition produces gasses within their body cavities. Unfortunately, these reports came to the attention of DFO much too late to be validated.

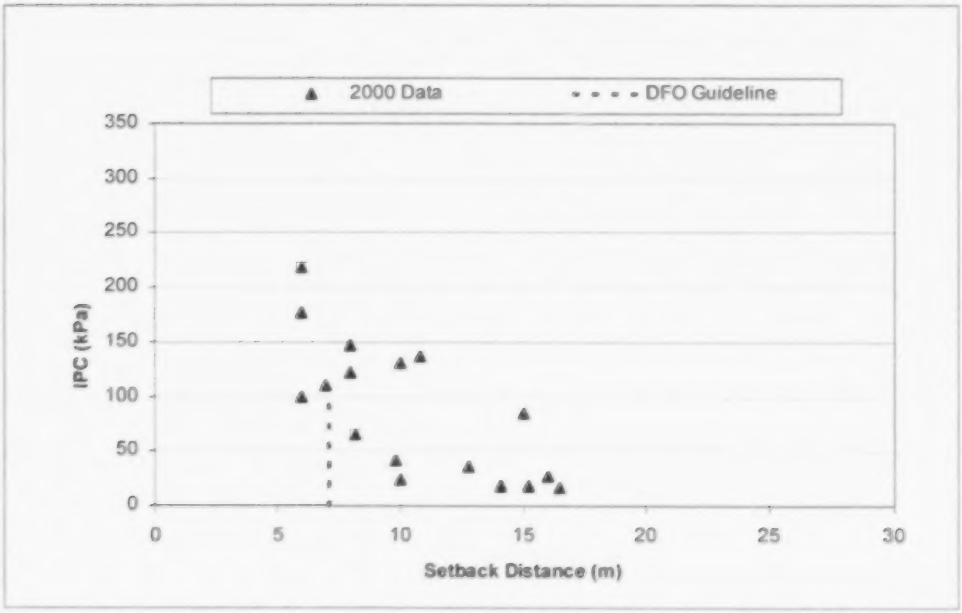

Figure 2: Instantaneous pressure change values (IPC) vs. setback distance for 2.0 kg charges recorded with Hydrophone 1, open water conditions (Aug. – Sept. 2000).

Several seismic programs using dynamite proceeded during the winter of 2000/2001 in the ISR. Industry followed the setback distances outlined within the Guidelines when shooting in areas of waterbodies not frozen to the bottom. One of the main types of equipment utilized for deploying charges under waterbodies was the Vibra-

ram®. Originally developed for use in the bayous of Louisiana, the Vibra-ram® uses a huge vibrating rod to deploy charges and was retrofitted for the Arctic by mounting it on a tracked vehicle. A charge is loaded at the end of the rod with a protective, detachable bit equipped with barbs. After a hole was augered through the ice, the ram pushed the charge into the lake bottom, and once the required setback distance was achieved, the rod was retracted (M. Swagar, WesternGeco *pers. comm.*). Industry began to have problems with charges not releasing at depth properly and rising up in the hole with the retracting ram. Concerned about exceeding the pressure thresholds outlined in the Guidelines, industry initiated an IPC monitoring program using Instatel® seismograph units with a three hydrophone placement (AquaScience 2001). DFO was notified once it was discovered that IPCs were indeed exceeding 100 kPa. Industry estimated that there were over 800 charges remaining in waterbodies that might not be buried to depth. Upon review of the IPC data collected, DFO advised that the setback distance for any new charges be increased to 8 metres or greater and given a minimum 72 hour sleep time to allow the shothole to collapse and fill in. Additionally, 20% of all charges yet to be detonated were to be monitored for IPC and sonic deterrent devices were to be utilized to scare fish from the area immediately preceding charge detonation. Of the 436 charges monitored for IPC, 50% exceeded 100 kPa and 74.6% exceeded 50 kPa (Figure 3). DFO subsequently recommended that the Vibra-ram® no longer be used when conducting seismic activities over waterbodies not frozen to the bottom in the NWT.

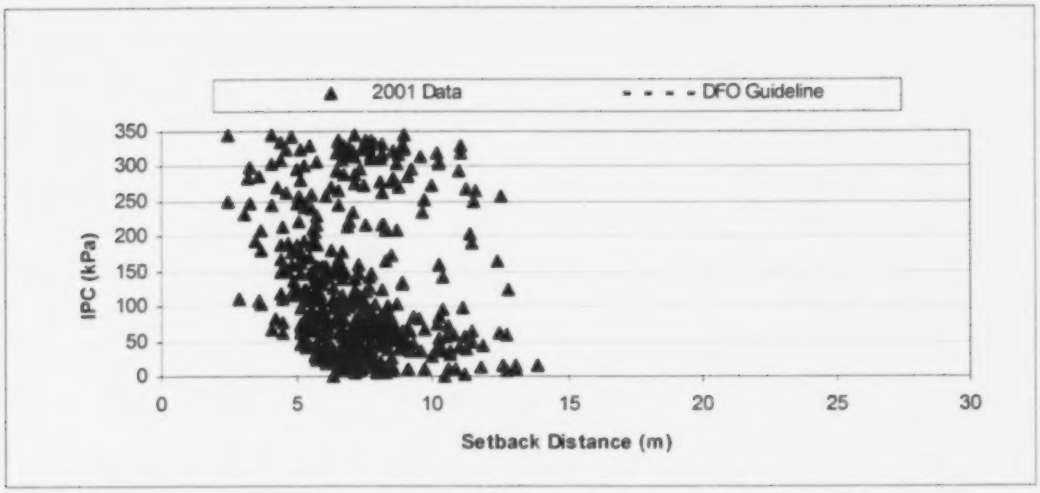

Figure 3. Instantaneous pressure change (IPC) values vs. setback distance for 2.0 kg charges recorded with Hydrophone 1, waterbodies not frozen to the bottom (Jan. – April 2001).

Lessons Learned

From the initial monitoring data received, a setback distance of 15 metres for a 2 kg charge appeared adequate to keep IPC below 100 kPa. Fifteen meters is approximately double the setback distance outlined in the Guidelines when using rock as the substrate type, yielding the most conservative value (Wright and Hopky 1998) (Appendix 1). IPC values varied greatly among program areas suggesting that the problems with overpressure were not limited to equipment or setback distance shortcomings.

It also became apparent that DFO requirements for IPC monitoring must be written very specifically in order to ensure that the need for mitigation is identified at the appropriate time. For example, it was not learned until the conclusion of some seismic programs that the requirement to monitor 20% of the charges detonated was achieved by the proponents leaving every fifth shot in place and returning at the end of the program to detonate and monitor the last 20% of the charges. This provided for monitoring of 20% of

the charges as required, however the data obtained, "after the fact", gave no room to apply additional mitigation as needed and was clearly contrary to the intent of the requirement. The frequencies of the sonic deterrent devices, employed prior to detonating shallow buried charges, were later determined to have been outside the hearing capabilities of fish, hence of little value as mitigation.

2001/2002

In order to better manage the potential impacts of seismic programs on fish and fish habitat, DFO sent a letter to oil and gas proponents on June 13, 2001 outlining requirements for the upcoming winter seismic season. These requirements included the use of proven technology (equipment that could operate in northern conditions and set a charge at depth and have it stay in place) and the use of proven mitigation to suppress the effects of a blast if a charge was shallow buried or to minimize potential fish exposure. An assessment of alternative methods for conducting the seismic program and mitigation considered, contingency plans, IPC monitoring, long-term aquatics monitoring, baseline studies on waterbodies likely to be encountered, and details on how the programs would be supervised were further requirements.

On October 23, 2001 DFO sent a follow-up letter to industry advising that the minimum setback distance for any charge set under waterbodies not frozen to the bottom would be twice the Guidelines, or 15 metres for a 2 kg charge. Industry invited DFO to observe drilling tests of several variations of conventional auger drills proposed for use in the upcoming season. All drills were capable of drilling to depth and deploying charges.

Some companies requested that they be allowed to conduct field-testing to show that they could achieve acceptable overpressure values using setback distances less than twice the Guidelines in their upcoming projects in the ISR. DFO conceded, and under Section 32 *Fisheries Act* Authorizations, outlined the parameters for IPC and water quality monitoring (both short-term and long-term) for tests specific to individual program areas to determine burial depth/charge size combinations adequate for protecting fish during the production programs. IPC monitoring was done as per the previous winter season, using Instatel® seismograph units with a three hydrophone placement. An IPC monitoring protocol was developed to help guide proponents and ensure consistent monitoring between proponents and projects (Appendix 2). Monitoring requirements for subsequent production programs were also outlined within the Authorizations. Setback distance and charge size combinations for full production seismic would be determined upon the outcome of each test as it was anticipated that acceptable setback distance/charge size combinations would vary from program to program. The 100 kPa threshold outlined in the Guidelines is the IPC that results in the direct mortality of the "average" fish species, some species are more resistant to IPC than others (D. Wright, DFO *pers. comm.*). DFO biologists in the Pacific Region required monitoring of IPC on a pile-driving operation in the Port of Vancouver after fish kills of Pacific herring (*Clupea harengus*) and juvenile Pacific salmon (*Oncorhynchus* sp.) were observed. The IPC responsible for the fish kills were <65 kPa. DFO Pacific Region is in the process of developing guidelines for pile-driving operations, including IPC threshold limits of 20-30 kPa (C. Salomi, DFO *pers. comm.*). To offer increased protection to fish a more

conservative IPC of < 50kPa was required as the target for seismic testing in the Mackenzie Delta.

Out of the 11 programs where testing was conducted, 10 programs had to increase their setback distances beyond twice the Guidelines, in some cases up to five times Guidelines (e.g. 24m setback for 2kg charge). DFO required regular monitoring reports be submitted to ensure that the setback distance/charge size combinations outlined after testing were adequate for the entire area of individual programs. In some instances setback distances were increased as the program encroached on different waterbodies in their program areas. The operations of one program were suspended by DFO until it could be demonstrated that IPC levels could be lowered. Sonic deterrents (using proper frequencies) were required immediately preceding all charges suspected of yielding high IPC. There were no proven mitigation measures employed during the 2001/2002 seismic season and very little baseline data were provided on the lakes within the program areas prior to the initiation of the projects.

Lessons Learned

Despite greatly increased setback distances, 8.7% of all detonations monitored produced IPC's in excess of 100kPa, and 15.8% exceeded 50 kPa (n = 507). Although there were some other charges experimented with, the majority of charges used in production seismic were 2 kg. (Figure 4).

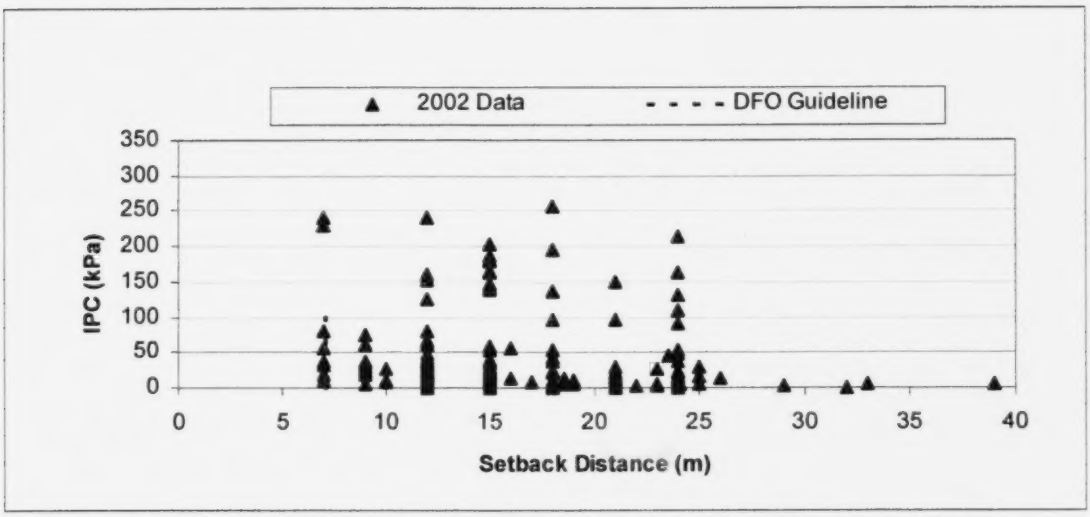

Figure 4: Instantaneous pressure change (IPC) values vs. setback distance for 2.0 kg charges recorded with Hydrophone 1, waterbodies not frozen to the bottom (Jan. – April 2002).

Explosive-induced IPC's are highly variable and are difficult to predict with any accuracy. Our experience in the Mackenzie Delta suggest that DFO's *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* may not work as intended and that the application of setback distances using the Guidelines does not ensure protection of fish during explosive denotation. Further, the blast extinction coefficient of pressure computed from hydrophone observations is highly variable from waterbody to waterbody even when the substrate appears to be similar (as recorded in drillers logs), and may explain the markedly different IPC values for some charges of similar size and setback. This is possibly due to variations of the substrata making it difficult to place confidence in IPC predictions when applying the general substrate values listed in the Guidelines.

In contrast, the last explosives-based seismic program near waterbodies approved in Alaska was in the late 1980s, the approval stipulated requirements for setback distances from the waterbody as well as IPC monitoring. Incidentally, this program was never conducted as the company withdrew the application. (A. Ott, Alaska Dept. of Fish

and Game *pers. comm.*). Current mitigation for seismic exploration in Alaska is very stringent. The following is outlined in the "Mitigation Measures and Lessee Advisories" put forth by the Alaska Department of Natural Resources – Division of Oil and Gas (Alaska Dept. of Natural Resources 2003):

> *Use of explosives will be prohibited in open water areas of fishbearing streams and lakes. Explosives must not be detonated beneath, or in close proximity to fishbearing streams and lakes if the detonation of the explosive produces a pressure rise greater than 2.5 pounds per square inch (psi) unless the waterbody, including it's substrates, is solidly frozen.*
> **Note:** 2.5 psi equals 17.2 kilopascal (kPa)

Water quality is not adversely affected by either drilling through the substrate or blasting. Turbidity, suspended solids and dissolved oxygen parameters exhibit a short-lived temporal and spatial increase (<3m, <10 minutes), or no change at all. Final results of the long term monitoring have not been received at time of writing, however interim reports suggest that seismic operations, using explosive charges set several metres below the substrate of a waterbody, do not alter selected water quality parameters.

With the increase in oil and gas exploration activity, the potential existed for negative impacts from water withdrawal to occur as many programs often used the same water source. Water withdrawal requirements for programs were stipulated under water licences issued, by the NWT Water Board, on a per day per program basis rather than a total volume per a given lake regardless of the users. Tremendous volumes of water are

required for drilling, winter road and access construction and camp use. Further complicating this issue was the fact that the vast majority of the lakes in the ISR are unnamed, making it difficult to track users. With so many access routes and seismic lines being constructed, several problems were also encountered with stream crossings that were not constructed to DFO specifications.

2002/2003 (up to April 30, 2003)

The inherent unpredictability and risk of using explosives in fish-bearing waters and the lack of proven mitigation prompted DFO – Western Arctic Area to draft a position statement that explosives should not be used to conduct seismic exploration in areas of waterbodies not frozen to the bottom in the NWT. This position was sent to Ottawa for review in July 2002. DFO- Western Arctic Area also developed two protocols:

1) DFO Protocol for Water Withdrawal for Oil & Gas Activities in the Northwest Territories (Appendix 3),

2) DFO Protocol for Temporary Winter Access Water Crossings for Oil & Gas Activities in the Northwest Territories (Appendix 4).

These protocols were developed by the authors in conjunction with staff from the Environmental Science and Conservation and Protection programs in DFO, with input from industry, the NEB and INAC. DFO has received some excellent bathymetry maps from industry for many lakes in the ISR. This information coupled with more precise water usage estimates helped DFO predict potential impacts to fish and fish habitats due to water drawdown. In many

instances, industry utilized the bathymetric maps frequently for project and route planning purposes.

During 2002/2003, exploration activities were greatly reduced in the Mackenzie Delta, however with increased activity in other areas of the territory the overall level of activity remained relatively constant. Only four seismic programs were planned for the ISR and all companies voluntarily proposed to use only non-explosive techniques and/or avoid lakes when using dynamite. Only two of the four seismic programs proceeded (one 2-D and one 3-D), both utilizing vibroseis as their primary energy source.

DFO – Western Arctic Area released its position statement that explosives should not be used to conduct seismic exploration in areas of waterbodies not frozen to the bottom in the NWT to industry on February 14, 2003 (Appendix 5).

Next steps

DFO will publish a technical report summarizing the IPC monitoring results from the explosives based seismic programs conducted in the NWT from 2000 to 2002. As data are sparse on lakes in the ISR, DFO will also produce a report compiling the bathymetry data recently collected in map form for future public usage. DFO has been invited to partner on an industry led study aimed at testing fish deterrent devices to be used as mitigation, ensuring that they are effective for use in northern lakes. Further investigation on impacts surrounding water withdrawal is also planned.

SUMMARY

After several seasons of regulating seismic activities in the NWT, many questions remain unanswered (e.g. will sonic deterrent devices scare fish effectively in winter conditions? can the factors that make explosive use unpredictable be isolated?), however, we are much further ahead than we were prior to 2000. For instance, we are now aware of the unpredictability and probable negative effects with using explosives in fish-bearing waters. We also now know that following the DFO *Guidelines for the Use of Explosives in or Near Canadian Fisheries Waters* does not offer the level of protection to fish that we thought it did; these Guidelines should be revisited.

The oil and gas industry as a whole was cooperative and compliant while conducting seismic exploration in the NWT. Fostering good working relationships with industry, other regulators and co-management partners was instrumental in effective management of seismic operations and the protection of the NWT's fisheries resources.

ACKNOWLEDGEMENTS

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Corporation; Darwin Monita and Aquatics; Chevron Canada; Conoco (formerly Gulf Canada); Delta Trace Ltd.; Devon (formerly Anderson Exploration); Encana (formerly AEC West Ltd.); Golder Associates; IMG – Golder Corporation; Inuvialuit Environmental and Geotechnical Inc., Dave Hannay and Jasco Research Ltd.; LGL Ltd., Petro-Canada; Shell Canada; Veri-Illuq Geophysical Ltd. and WesternGeco. Also, Colin Lake of Kestrel Biological Consulting for his help with the figures, Dave Levy of Levy Research Services Ltd. for his assistance with statistical analysis and Elva Simundsson with her greatly appreciated assistance in the production of this manuscript. Our apologies to anyone who was missed above.

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Table of Contents / Chapter 1 / Chapter 2 / Chapter 3 / Chapter 4 / Chapter 5 / Chapter 6 /
Table 1 / Table 2 / Appendix I / Appendix II / Appendix III / Appendix IV / Appendix V

Erratum: Updated as of December 6, 2000

Wright, D.G., and G.E. Hopky. 1998. Guidelines for the use of explosives in or near Canadian fisheries waters. Can Tech. Rep. Fish. Aquat. Sci. 2107: iv + 34p.

Table 1. Setback distance (m) from centre of detonation of a confined explosive to fish habitat to achieve 100 kPa guideline criteria for various substrates.

Substrate Type	Weight of Explosive Charge (kg)							
	0.5	1	2	5	10	25	50	100
Rock	3.6	5.0	7.1	11.0	15.9	25.0	35.6	50.3
Frozen Soil	3.3	4.7	6.5	10.4	14.7	23.2	32.9	46.5
Ice	3.0	4.2	5.9	9.3	13.2	20.9	29.5	41.8
Saturated Soil	3.0	4.2	5.9	9.3	13.2	20.9	29.5	41.8
Unsaturated Soil	2.0	2.9	4.1	6.5	9.2	14.5	20.5	29.0

Table of Contents / Chapter 1 / Chapter 2 / Chapter 3 / Chapter 4 / Chapter 5 / Chapter 6 /
Table 1 / Table 2 / Appendix I / Appendix II / Appendix III / Appendix IV / Appendix V

APPENDIX 2

Fisheries and Oceans / Pêches et Océans

DFO Western Arctic Area 2001/2002 Protocol for Monitoring the Use of Dynamite in Waterbodies not Frozen to the Bottom

1. No fewer than 10% of production shot holes occurring in areas where waterbodies are not frozen to the bottom shall be monitored. The 10% of shot holes shall be allocated between separate waterbodies and different areas of the project at different times in order to be as representative of the operation as possible.

2. Monitoring crews shall determine ice thickness, water depths as well as blasting cap lead lengths remaining at the surface and shall be recorded for all monitored holes.

3. Total suspended solids (TSS) is required to document water clarity of both pre and post drill and blast seismic activity. DFO's main objective is to determine if these seismic activities result in localized increases. Monitoring crews shall ensure pre and post values are consistently obtained. All water clarity measurements shall be taken ***in situ***, 25 cm above the waterbody substratum at the shot hole site.

4. Dissolved oxygen (DO) measurements shall be recorded at the shot hole location prior to any drilling and immediately upon completion of drilling (approximately within 2 minutes of the extraction of the drill stem/casing from the hole). All DO measurements shall be taken ***in situ*** 25 cm above the waterbody substratum at the shot hole site.

5. Charge depths shall be confirmed prior to and after the charges are loaded using appropriate methods (e.g.- weighted measuring line, loading pole, etc). Depth shall be calculated from the start of the consolidated layer to the top of the buried charge.

6. All charges shall have anchoring firmly secured to prevent their up-hole migration from occurring.

7. Fish deterrents, approved in advance by DFO staff, shall be available to be implemented on site to prevent the harmful effects to fish from the aspects of an Instantaneous Pressure Change (IPC) over 100kPa if anticipated from an explosive charge.

8. IPC monitoring equipment used shall have a minimum sampling frequency of 16,000 measurements per second per hydrophone to be able to provide the best possible estimate of peak pressure change in the water column.

9. Valid and up-to-date calibration certificates for IPC sensing equipment that is used for monitoring shall be submitted to DFO prior to their use in monitoring.

10. IPC sensing equipment shall be inspected daily prior to monitoring events to ensure that they are operating to manufacturer's specifications.

11. The IPC in the water column shall be monitored at X m, X+5m and X+10m from the buried charge. The following table specifies the setback placement of the three hydrophones for each charge at varying depths of charge. Each hydrophone shall be set approximately 15 cm above the waterbody substratum.

Burial Depth (BD)	SETBACK DISTANCE FOR HYDROPHONES		
	1 0 meters (at shothole)	2 BD+ 5 meters	3 BD + 10 meters
7 meters	0 m	9.7 m	15.5
9 meters	0 m	10.7 m	16.7 m
12 meters	0 m	12.0 m	18.4 m
13 meters	0 m	12.5 m	19.0 m
14 meters	0 m	12.8 m	19.5 m
15 meters	0 m	13.2 m	20.0 m
16 meters	0 m	13.6 m	20.5 m
18 meters	0 m	14.3 m	21.4 m
20 meters	0 m	15.0 m	22.4 m
21 meters	0 m	15.3 m	22.8 m
22 meters	0 m	15.7 m	23.2 m
24 meters	0 m	16.3 m	24.1 m
26 meters	0 m	16.9 m	24.9 m
28 meters	0 m	17.5 m	25.7 m
32 meters	0 m	18.6 m	27.2 m
34 meters	0 m	19.1 m	27.9 m
36 meters	0 m	19.6 m	28.6 m

12. Any IPC value obtained over 100kPa in the water column caused by an explosive charge shall result in ceasing of further setting of charges until DFO is immediately notified and approval secured to continue operations.

13. All results from monitoring shall be submitted to DFO as expeditiously as possible. A preliminary spreadsheet (format .xls) of test results shall be submitted to DFO within 3 calendar days of test completion. This spreadsheet shall contain sampling dates and locations with all monitoring parameters recorded along with a copy of the driller's record log.

14. A final report of all testing and production monitoring in both hard copy and WORD (.doc.) format (excluding corporate trademarks) shall be submitted by June 1st, 2002 and include the original IPC records in their digital format on a CD-ROM.

This letter must be kept on site during any work in or around water and be understood by staff working at the site.

APPENDIX 3

Fisheries and Oceans / Pêches et Océans

DFO Protocol for Water Withdrawal for Oil & Gas Activities in the Northwest Territories

The following information must be provided to DFO for review and project approval prior to program commencement.

Information Requirements

Water Source Identification

1) Primary and secondary access routes with water source locations are to be clearly identified on a map. Consistency in water-source identification is to ensure that your crews and other operators in the area using the same water-source will not be in conflict by using the same source independently.
2) Document how and whether there is watercourse connectivity (permanently flowing or seasonal) between the proposed water-source to any other water body.

Bathymetric Determination

3) For all water bodies: One 'e-line' transect, regardless of waterbody size, done in open water conditions using an echo sounder with continuous depth recording capabilities to the bottom sounded from shore to farthest opposing shore. Depth of lake requires the incorporation of the depth that the transducer is positioned below the water surface.
4) For lakes less than 1km in length: Two transects (dissecting the water body into thirds) perpendicular to the 'e-line' and regardless of size, done in open water conditions using an echo sounder with continuous depth recording capabilities to the bottom.
5) For lakes 1km or greater in length, at least one 'e-line' transect (shore to farthest opposing shore) should be run with an echo sounder and perpendicular transects (shore to shore) done at maximum intervals of 500m.
6) Regardless of lake size, additional transects be run as required to include irregularities in water body shape (e.g., fingers or bays) or irregular basin depths.

Volume Calculations

7) Document how surface area was calculated. If aerial photos were used, provide the date (month/year) that the photo was taken as surface area may change depending on the time of year. Provide the year of datum if maps were used. Detail how volume was determined, incorporating the field bathymetry.
8) Use 2.0m ice thickness in volume calculations (total volume minus 2.0m of ice cover) to account for water volume that will be unavailable. 2.0 m is the maximum expected ice thickness expected and will represent end of winter conditions.

General Mitigation

Water Source Identification

1) Streams, excluding the Mackenzie River and channels, are to be avoided as a water-source unless site specific permission is given by DFO.
2) Any water bodies that are less than 1.5m in depth with no connectivity may be used since the potential for fish over-wintering habitat would be low.
3) No water should be removed from water bodies that are between 1.5 and 3.7 m in maximum depth.
4) Total seasonal water removal per waterbody is not to exceed 5% of the free water (under ice volume using 2.0m ice thickness) available in the water body, regardless of the number of operators utilizing the waterbody.

Water Withdrawal

5) Water removal is to take place in the deepest portion of the lake reasonably and safely accessible, avoiding removal of oxygenated water and minimizing the potential for fish entrainment.
6) 2.54 mm (1/10") screened mesh size on intake end of pipe is recommended. Other dimensions for intake screens may be determined following calculations outlined in DFO's *Freshwater Intake End-of-Pipe Fish Screen Guidelines* and ensuring that these calculations, complete with pump specifications, are maintained on-site at the pumping location.

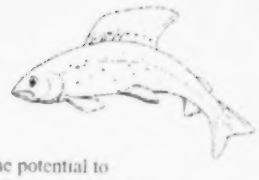
Any deviations from the above must be submitted to DFO and will be dealt with on a site-specific basis (e.g. additional bathymetric data collected during the winter).

For more information contact DFO at (867) 777-7520/7521, or (867) 669-4931.

APPENDIX 4

Fisheries and Oceans / Pêches et Océans

DFO Protocol for Temporary Winter Access Water Crossings for Oil & Gas Activities in the Northwest Territories



Rational:
The construction and subsequent removal of temporary winter access water crossings have the potential to negatively impact fish and fish habitat. The clearing of bank vegetation can remove overhead cover and lead to bank instability. When the banks of watercourses are disturbed, erosion can result, depositing sediments on important fish habitat such as spawning areas.

The same habitat disturbance could result from using materials other than ice or snow to make the crossings. Crossings that are not removed prior to spring freshet could create impassible barriers for fish movements such as migrations to critical spawning or nursery grounds. Also, bank and bed erosion can occur when the spring freshet waters are forced around any blocked watercourse.

Therefore, it is imperative that winter access water crossings are constructed and removed properly to protect fish and fish habitat.

Mitigation for Snow and Ice Crossings:

1. Every effort should be made to retain riparian vegetation, as it is a critical component of fish habitat providing overhead cover as well as maintaining bank stability. Access routes should follow existing trails, winter roads or cut lines wherever possible, avoiding unnecessary clearing of vegetation.

2. Winter crossings should not impede water flow at any time of year and be v-notched, or completely removed prior to spring break-up.

3. No material should be left on the ice when there is the potential for that material to enter the water (i.e. spring break-up).

Alternative Crossing Material:
If adequate snow is unavailable a Fishery Officer may Authorize the use of brush and slash from seismic line clearing that is free of any other material (i.e. dirt). The following points should be followed when seeking Authorization:

4. DFO is notified in writing of the intent to use slash from seismic access routes (not riparian cover) to supplement snow and ice to make a crossing and is provided updated lists of crossings as the season progresses and more crossings are added.

5. Every water crossing, including ones constructed using ice and snow, is be documented and their location (Lat, Long or UTM) and length identified on a map and provided to DFO.

6. The number of crossings is minimized to the furthest extent possible, and the number of instances where materials other than ice or snow are used to make crossings is also minimized.

7. All crossing are removed carefully before spring freshet and documented with before and after removal photos.

8. DFO is kept advised on the status of removal.

Any requests deviating from the above will be dealt with on a case by case basis.

PLEASE NOTE: Unless authorized (in writing) by a Fishery Officer, the use of material other than ice or snow to construct a temporary crossing-over an ice-covered stream is prohibited under Section 11 of the *Northwest Territories Fishery Regulations*.

For more information contact DFO at (867) 777-7506 or (867) 777-7520.

Canada

APPENDIX 5

Fisheries and Oceans / Pêches et Oceans

Fish Habitat Management
101-5204-50th Ave.
Yellowknife, NWT
X1A 1E2

Your file *Votre référence*

Our file *Notre référence*
SC02055

February 14, 2003

SEE ATTACHED DISTRIBUTION LIST

RE: DFO Recommendation - Explosives Should Not Be Used To Conduct Seismic Exploration In Areas Of Waterbodies Not Frozen To The Bottom

Fisheries and Oceans Canada (DFO) has received test and monitoring results of the instantaneous pressure changes (IPC) associated with the use of explosives during various seismic programs conducted in the Mackenzie Delta, Northwest Territories, during the summer of 2000 and the 2000/2001 and 2001/2002 winter seasons.

IPC testing and monitoring was conducted to determine the results of charge size and setback combinations. The data collected indicate that it is extremely difficult to confidently predict IPC that would be in a safe range for fish. Furthermore, no mitigation proposed to date has been successfully demonstrated to minimize the potential harmful effects of a detonated charge to fish and fish habitat under winter conditions.

DFO has concluded that the use of explosives to conduct seismic exploration on areas of waterbodies not frozen to the bottom may result in significant negative effects on fish and fish habitat. Therefore, DFO will not authorize the use of explosives in the NWT to conduct seismic exploration in areas of waterbodies not frozen to the bottom.

If you are planning to conduct seismic operations in or around waterbodies, please contact DFO Fish Habitat Management staff in the Western Arctic Area.

Sincerely

Ron Allen
Area Director, Western Arctic Area
Department of Fisheries and Oceans

Attachment: Distribution List

Copy:
R. J. Pierce - Regional Director General, Central and Arctic Region – DFO
Jeff Stein – Director, Habitat Management, Central and Arctic Region – DFO
Julie Dahl – Area Chief, Habitat, Western Arctic Area – DFO
Pete Cott – Area Habitat Biologist, Western Arctic Area – DFO

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